



# Overview of the WESTCARB Geologic Pilot Tests

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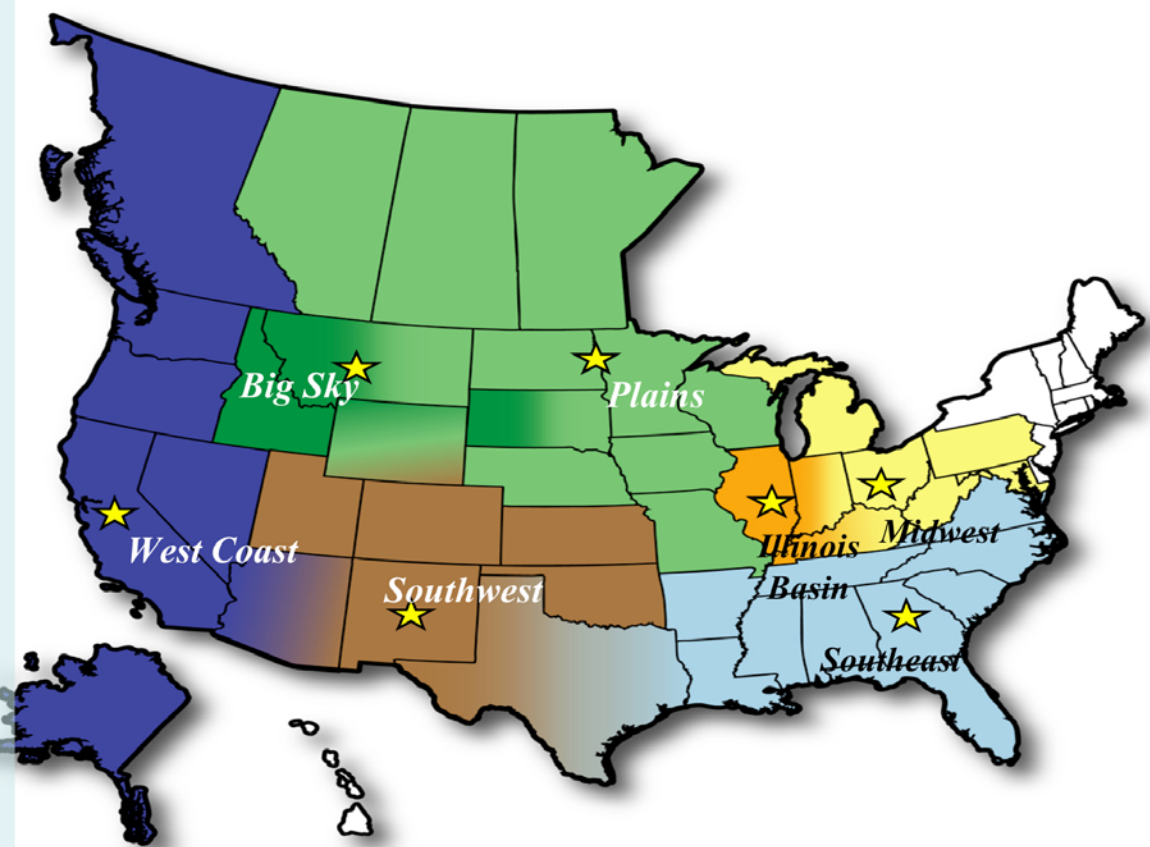
**<sup>3</sup>Stanford University**

*Fourth Annual California Climate Change Conference  
Sacramento, CA  
September 10–13, 2007*



# WESTCARB One of Seven DOE Regional Sequestration Partnerships

- Goal is to assess regional opportunities for terrestrial and geologic CO<sub>2</sub> storage
- WESTCARB plans to conduct three geologic pilot tests:
  - Rosetta Resources Saline Formation and Gas Reservoir Pilot Tests
  - Arizona Utilities CO<sub>2</sub> Storage Pilot Test



# WESTCARB Pilot Test Objectives

- Develop method for imaging extent of CO<sub>2</sub> in the subsurface
- Assess seal integrity
  - Caprock
  - Faults
- Determine injectivity and storage capacity of the reservoir
- Assess potential environmental impacts
  - Surface leakage
  - Groundwater
- Validate multiphase flow models







# WESTCARB Geologic Pilot Tests

## Rosetta Resources CO<sub>2</sub> Storage Project

*Rosetta Resources, Inc.*

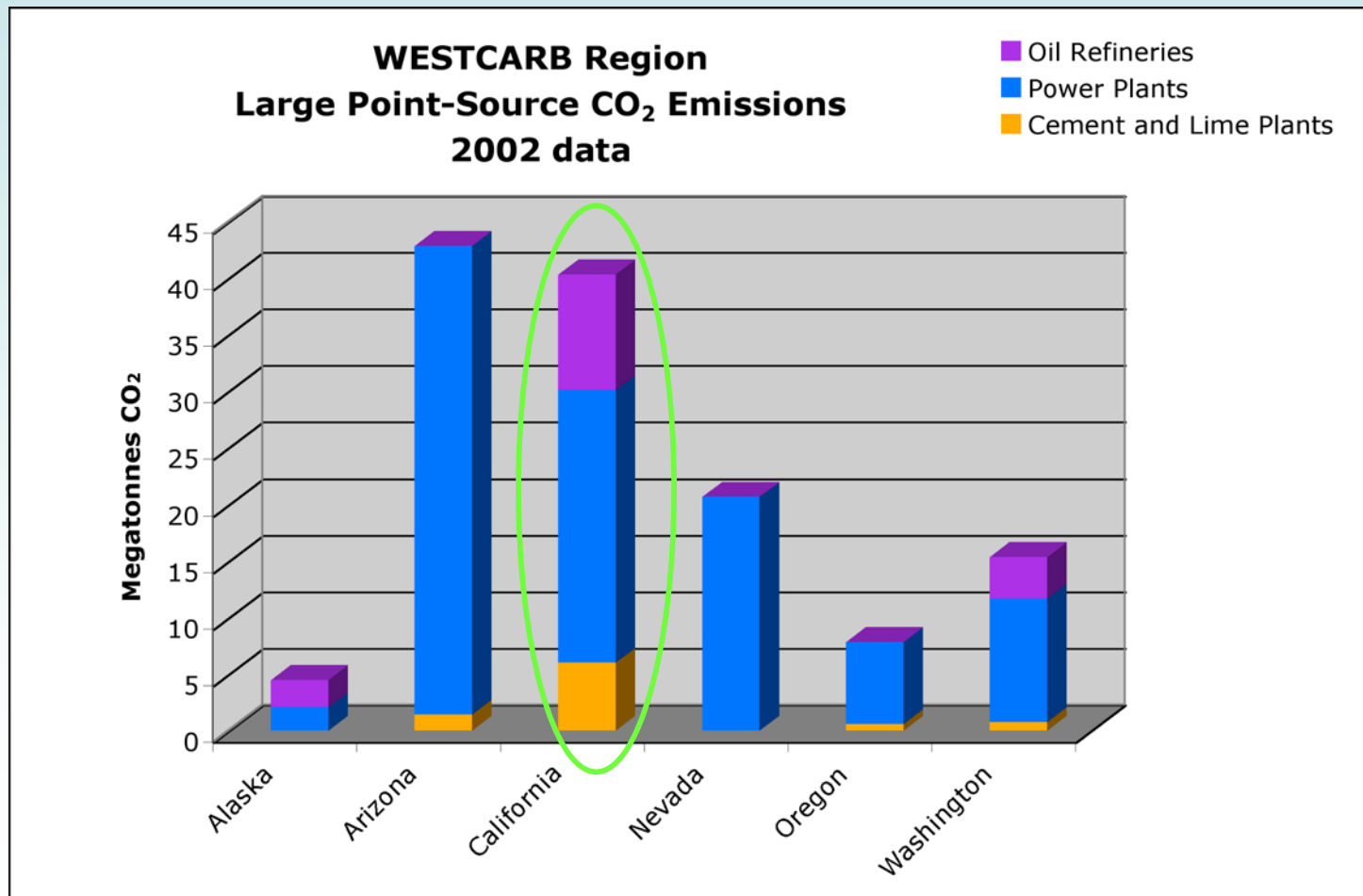
*California Energy Commission*

*Lawrence Berkeley National Laboratory*

*US Department of Energy*

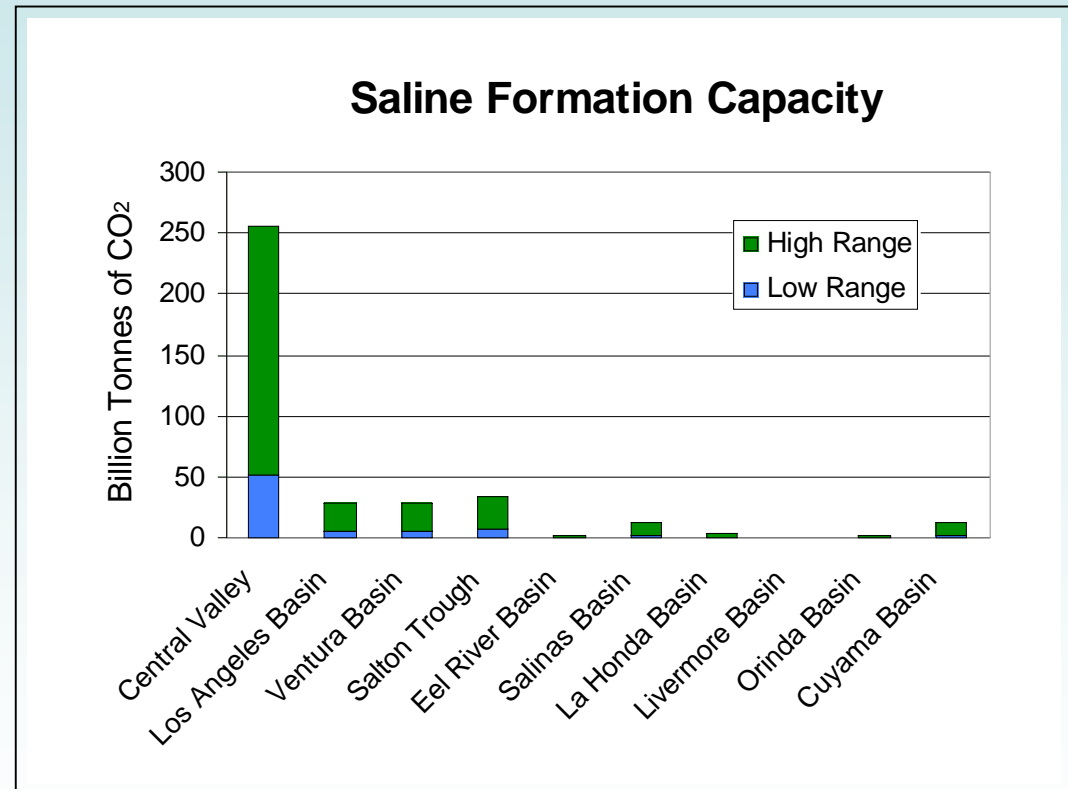


# California Large Point-Source CO<sub>2</sub> Emissions



# CO<sub>2</sub> Storage Capacity in California

- Oil Reservoirs
  - 3.8 billion tonnes
- Gas Reservoirs
  - 1.8 billion tonnes
- Saline Formations
  - 75 to 300 billion tonnes



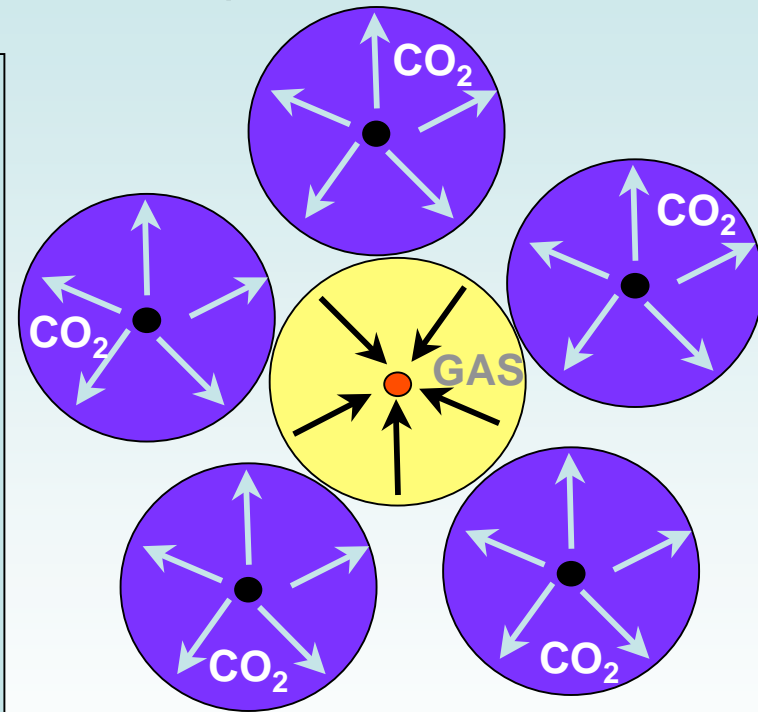
# Rosetta Pilot Test Enhanced Gas Recovery Research

## ■ CO<sub>2</sub> Storage Enhanced Gas Recovery (CSEGR)

### Primary Mechanisms

- Repressurize depleted natural gas reservoir using CO<sub>2</sub>
- Use CO<sub>2</sub> to sweep natural gas toward producing wells

### Depleted Gas Field

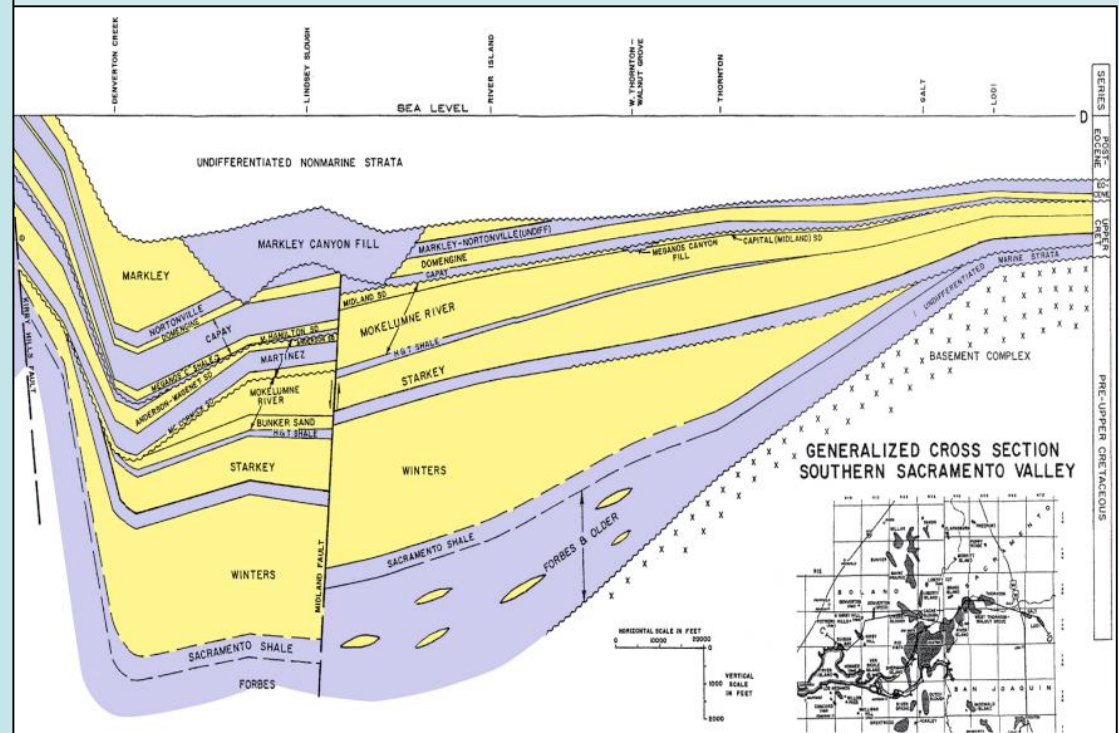


- Gas production
- well
- CO<sub>2</sub> injection well



# Sacramento Basin Province

- Numerous depleted and active gas fields throughout province
- Located in the Central Valley near large point sources
- Numerous thick reservoirs capped by low permeability seals
- Seismic stability is relatively good



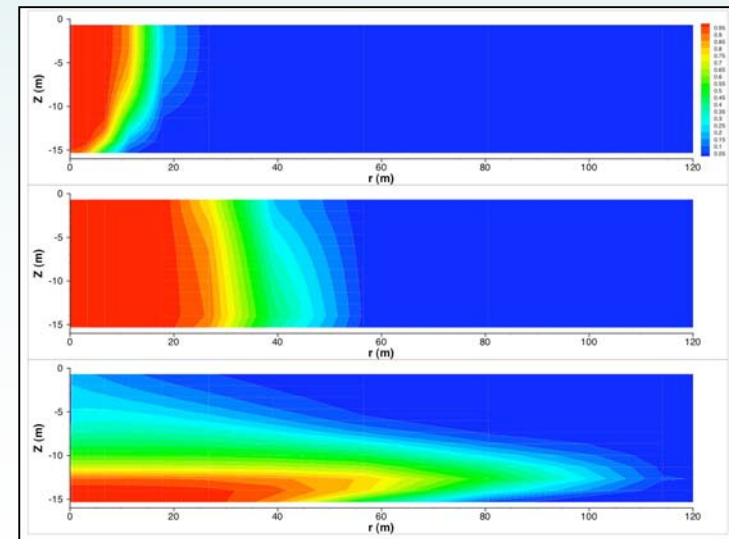
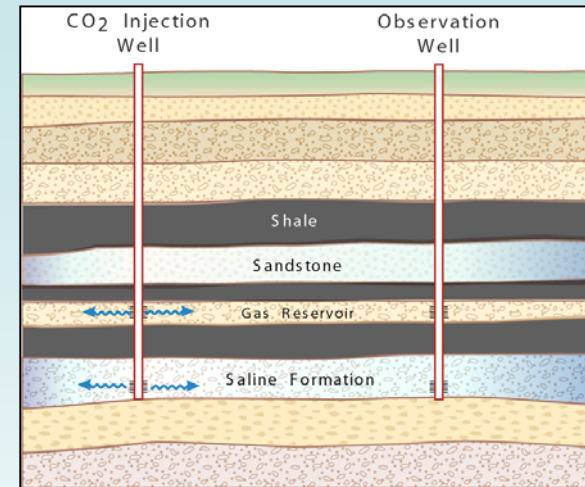
(modified from DOG, 1983)





# What Are We Proposing to Do? (Rosetta Pilot)

- Drill two wells about 4000 ft deep penetrating a stacked reservoir
- Inject up to 2000 tonnes of CO<sub>2</sub> into a Saline Formation
- Seal off the Saline Formation
- Perforate gas reservoir and inject up to 2000 tonnes of CO<sub>2</sub> again
- Assess injectivity and storage capacity
- Model validation



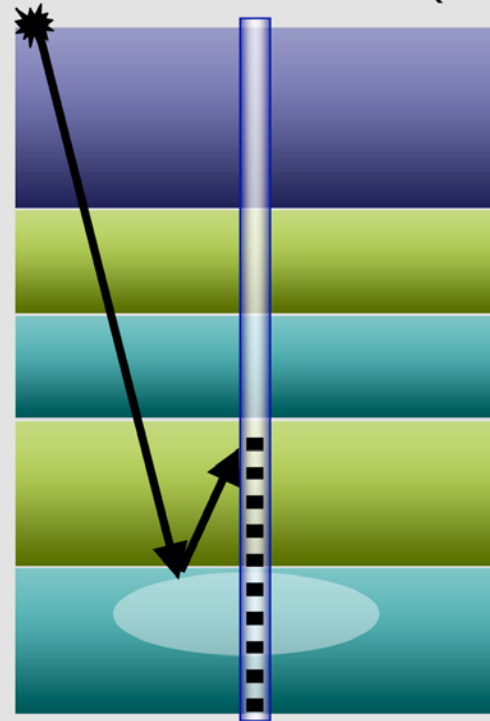
TOUGH2 Multiphase Flow Model



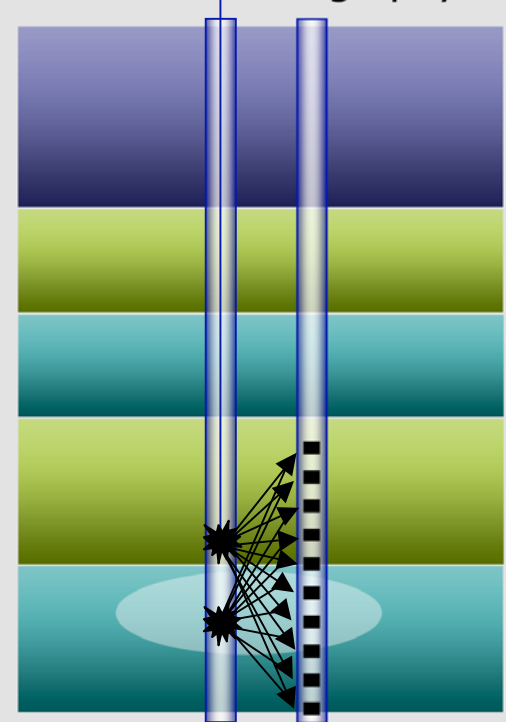
## What Are We Proposing to Do? (continued)

- Image CO<sub>2</sub> in the subsurface using seismic techniques
  - Vertical seismic profiling (VSP)
  - Cross-well seismic
- Share results with the community
- Plug and abandon wells after completing the project

Vertical Seismic Profile (VSP)



Cross-Well Tomography





# WESTCARB Geologic Pilot Tests

## Arizona Utilities CO<sub>2</sub> Storage Pilot



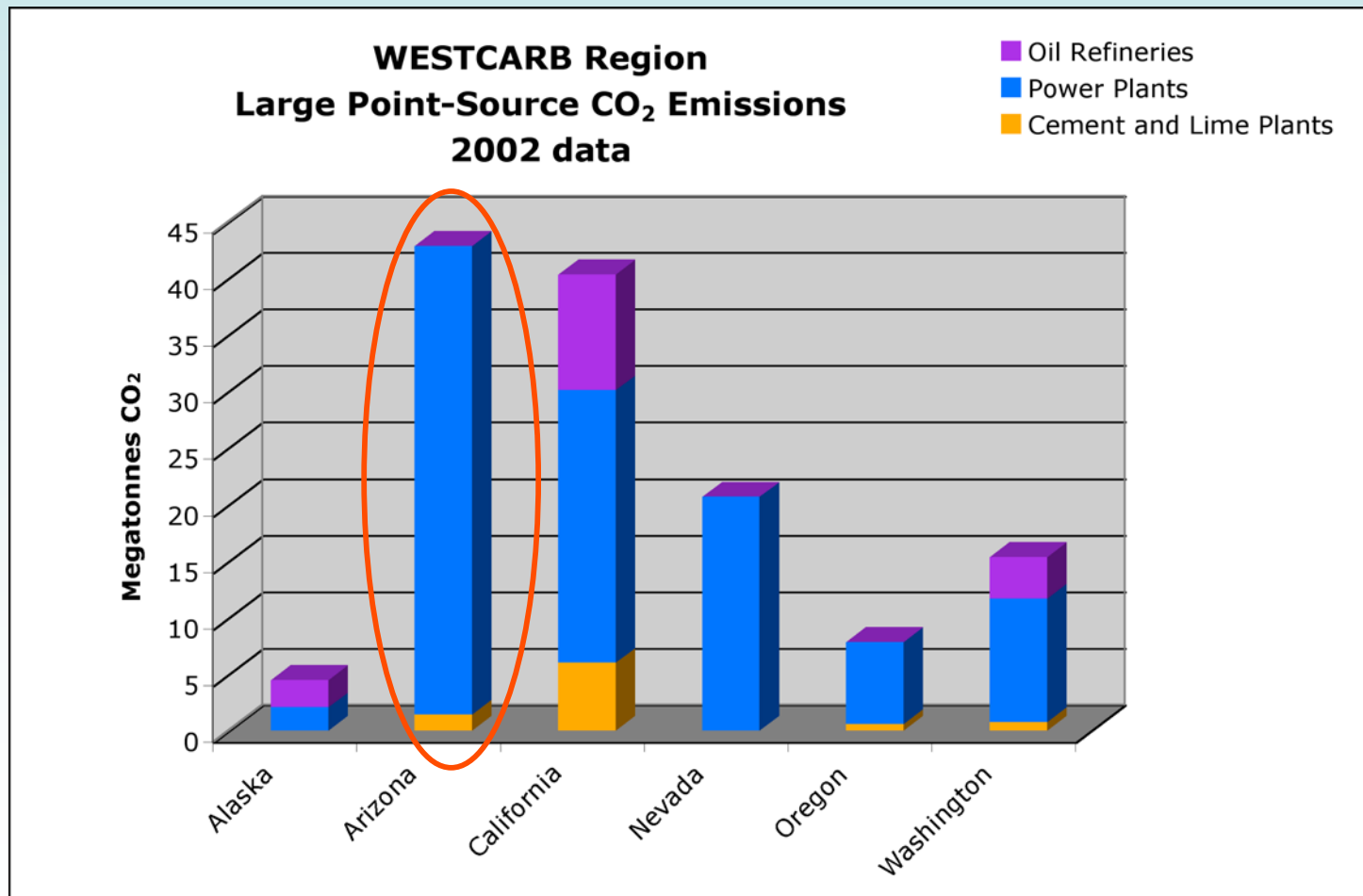
*Arizona Public Service Company  
Electric Power Research Institute  
Salt River Project  
Tucson Electric Power*



A UniSource Energy Company



# Arizona CO<sub>2</sub> Emissions Are Primarily From Coal-Fired Power Plants

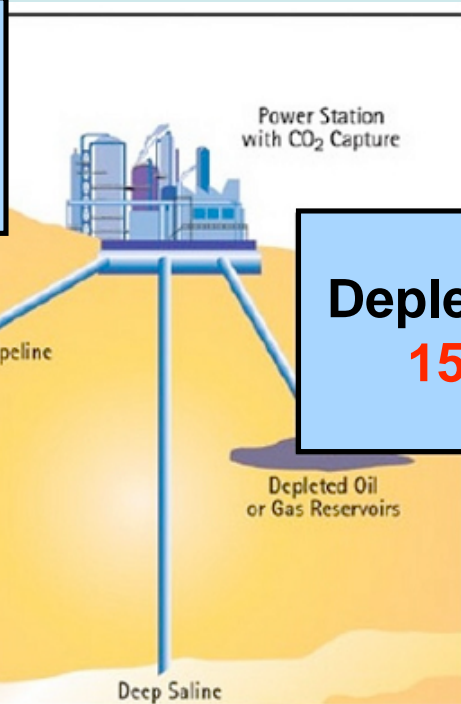




# Arizona Geologic Storage Potential

(Arizona Geological Survey)

**All Arizona Power Plants**  
**2002 Emissions (EPA)**  
**45 million tons CO<sub>2</sub>**



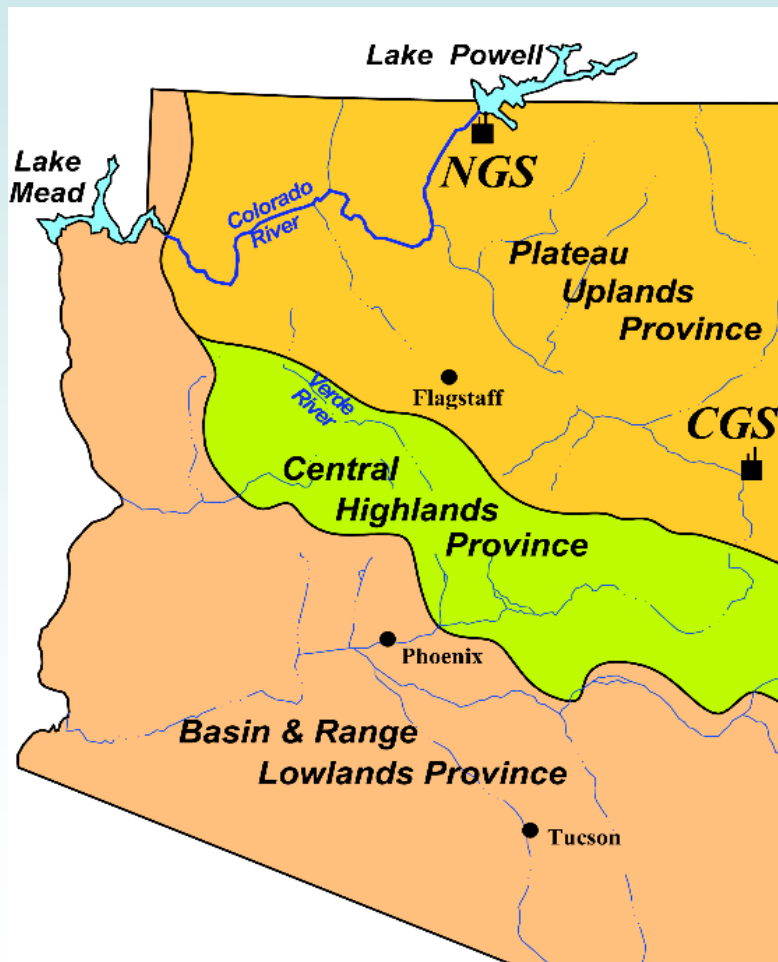
**Depleted Oil & Gas Fields**  
**15 million tons CO<sub>2</sub>**

**Unmineable Coal Seams**  
**Not a potential CO<sub>2</sub>**  
**storage option**

**Deep Saline Aquifers**  
**30,000 million tons CO<sub>2</sub>**



# Arizona Geologic Provinces



## Basin and Range Province

- Overall potential for geologic sequestration is likely to be poor

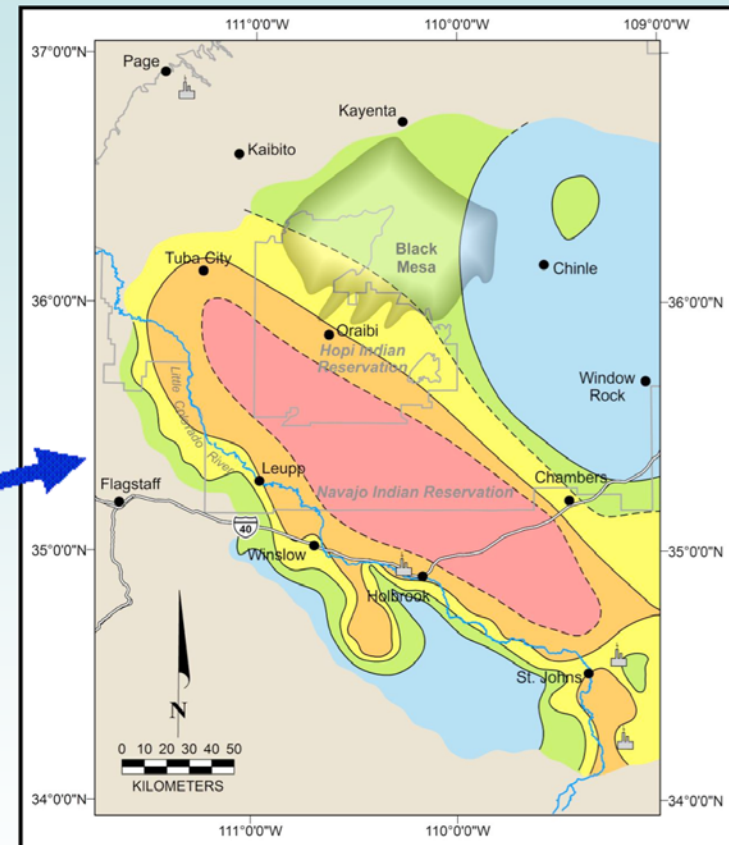
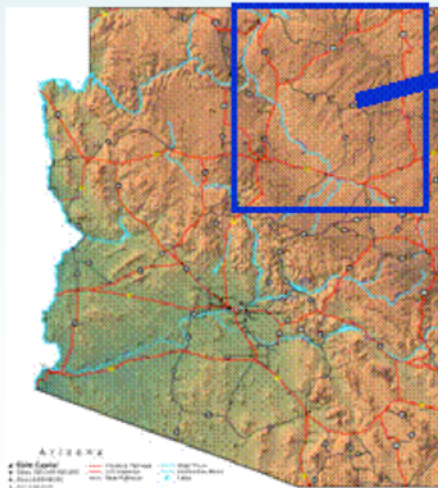
## Colorado Plateau Province

- Thick sequence of laterally extensive, nearly flat-lying sedimentary strata
- Some structural deformation
- Some areas of coal, oil, and gas accumulations



# Arizona Groundwater Resources

- Proposed project location near Cholla Power Plant overlies an area of nonpotable saline water



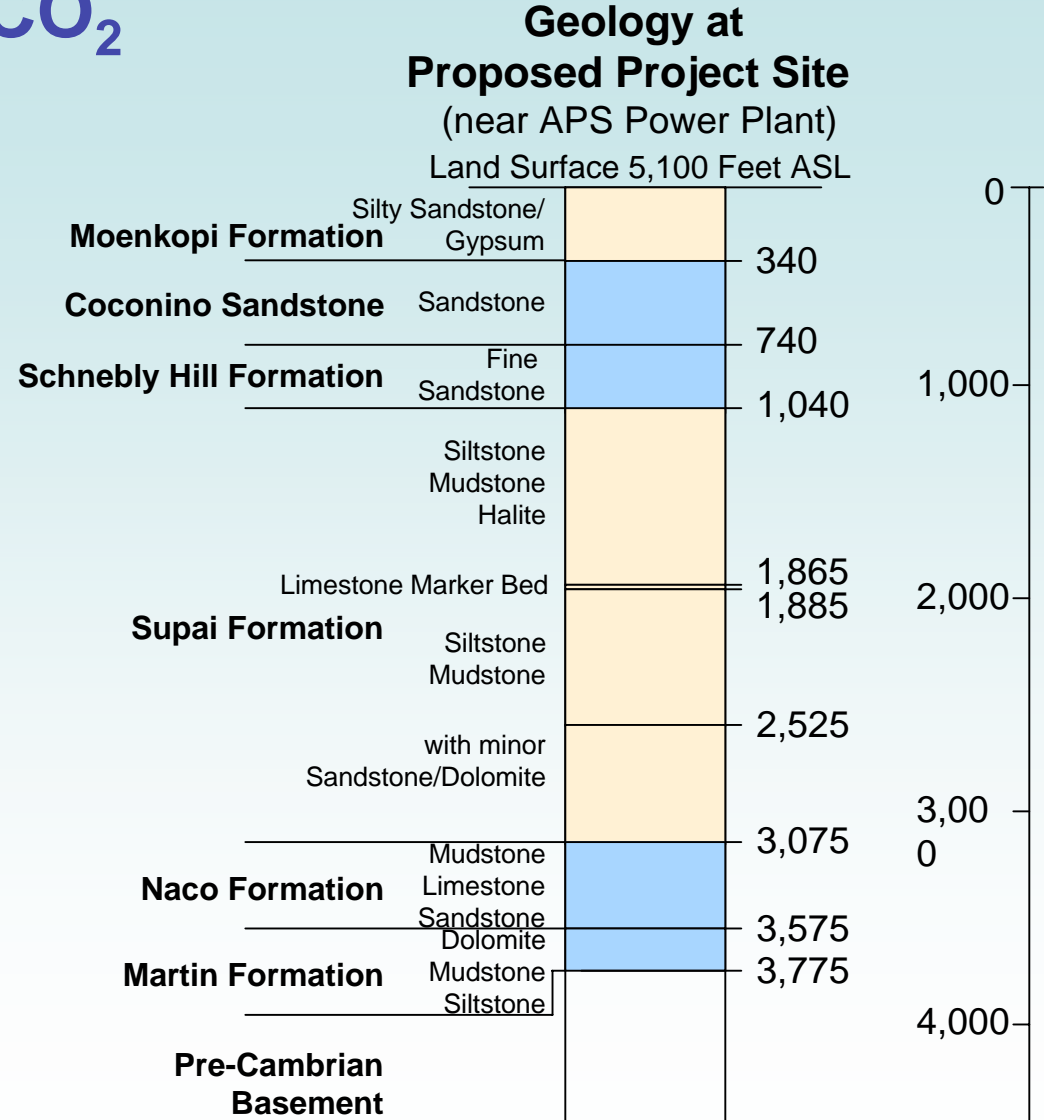
Distribution of dissolved solids in Coconino/DeChelly Sandstone

Source: Errol L. Montgomery & Associates



# Arizona Utilities CO<sub>2</sub> Storage Pilot

- Deep porous formations (Naco and Martin) minimize potential for leakage into shallower groundwater aquifers
- Injection test simulates a commercial operation where a single deep injection well may be the only well present



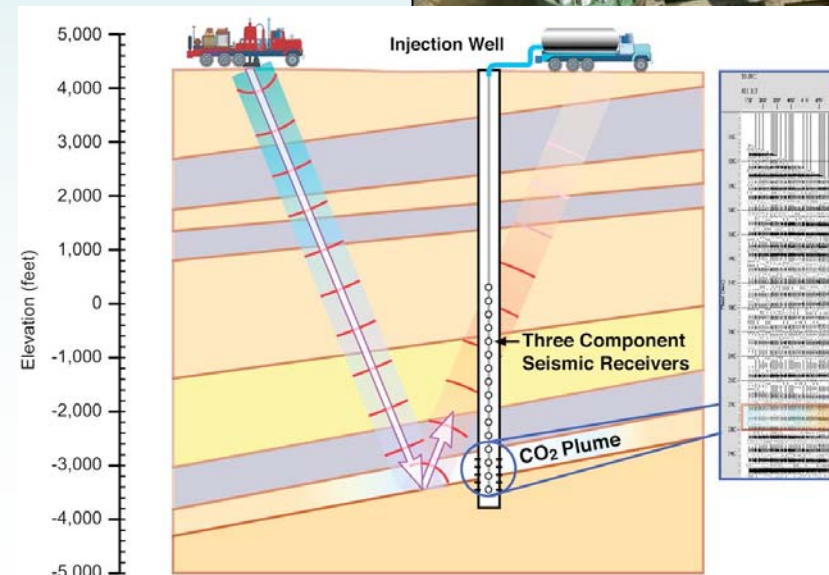
Source: Errol L. Montgomery & Associates





# What Are We Proposing to Do? (Arizona Pilot)

- Drill a single well about 4000 ft deep near an ash storage pond about a mile north of APS's Cholla Power Plant
- Truck in commercial-grade CO<sub>2</sub> and inject it into the well
- Monitor the CO<sub>2</sub> movement in the subsurface using seismic techniques and check for surface leaks
- Exploratory nature given the lack of available data



## What Are We Proposing to Do? (cont'd)

- Share our results with the community and public officials; compare our results with those from 25 similar tests across the United States and Canada
- Seal the well upon completion of the project in accordance with Arizona law
- Conduct outreach to educate and receive input from the public regarding climate change and geologic sequestration



# Summary

The WESTCARB project is ...

- Negotiating site access for the California Pilot
  - Preparing permit applications for the Arizona Pilot
  - Providing information to state and federal regulators
  - Reaching out to the community through public meetings
  - Developing site-specific models
  - Ordering test equipment/services
- ...and will begin
- ... testing in 2008

WEST  
COAST  
REGIONAL  
CARBON  
SEQUESTRATION  
PARTNERSHIP  
[westcarb.org](http://westcarb.org)



## PUBLIC MEETING

Storing Carbon Dioxide to  
Fight Global Warming:  
Arizona Utilities CO<sub>2</sub>  
Storage Pilot Project

Holbrook, Arizona, August 1, 2007, 6:30-8:00 p.m.

### Purpose

This informational meeting is being held to discuss plans for a research project to test "carbon sequestration," a promising new technology that can keep carbon dioxide (CO<sub>2</sub>) away from the atmosphere to curb global warming. Also known as CO<sub>2</sub> storage, carbon sequestration involves injecting CO<sub>2</sub> about 1/2 mile underground into porous geologic formations suitable for secure long-term storage. In Arizona, well-sealed, deep-lying formations such as limestone, mudstone, and sandstone are excellent candidates for CO<sub>2</sub> storage. The depth and high salinity of the water in these formations rule out the practicality of using it for human consumption or agriculture. The proposed

CO<sub>2</sub> storage test in northeast Arizona will inject a small amount of commercial-grade CO<sub>2</sub> into a dedicated well equipped with sensitive monitoring instrumentation. This will allow researchers to "see" the CO<sub>2</sub> as it is absorbed into the porous rocks. Successful subsurface geologic tests would help confirm the feasibility of ultimately storing CO<sub>2</sub> captured from nearby power plants, which could be required by future regulations.

**Everyone is welcome to attend the meeting to learn and ask questions about our proposed project. [Please see our Q & A section on the back of this announcement.]**



### MEETING LOCATION

Northland Pioneer College  
Fitness Center Building  
2251 N. Navajo Boulevard  
Holbrook, AZ 86032  
Meeting Contact: Danny Gradle, APS-Cholla Power Plant  
Telephone: 928-288-1541; Email: [DannyGradle@aps.com](mailto:DannyGradle@aps.com)



WEST COAST REGIONAL CARBON SEQUESTRATION PARTNERSHIP

